Jerome Landslide

POTENTIAL CAUSES OF LANDSLIDE AND PROBABILISTIC APPROACH TO ASSESSING FUTURE RISK OF MOVEMENT

Scott D. Neely, P.E.
Geotechnical Services Manager
Terracon, Inc
&
ADOT Materials Group

The Old Landslide Scarp

Existing Conditions

Model of Jerome

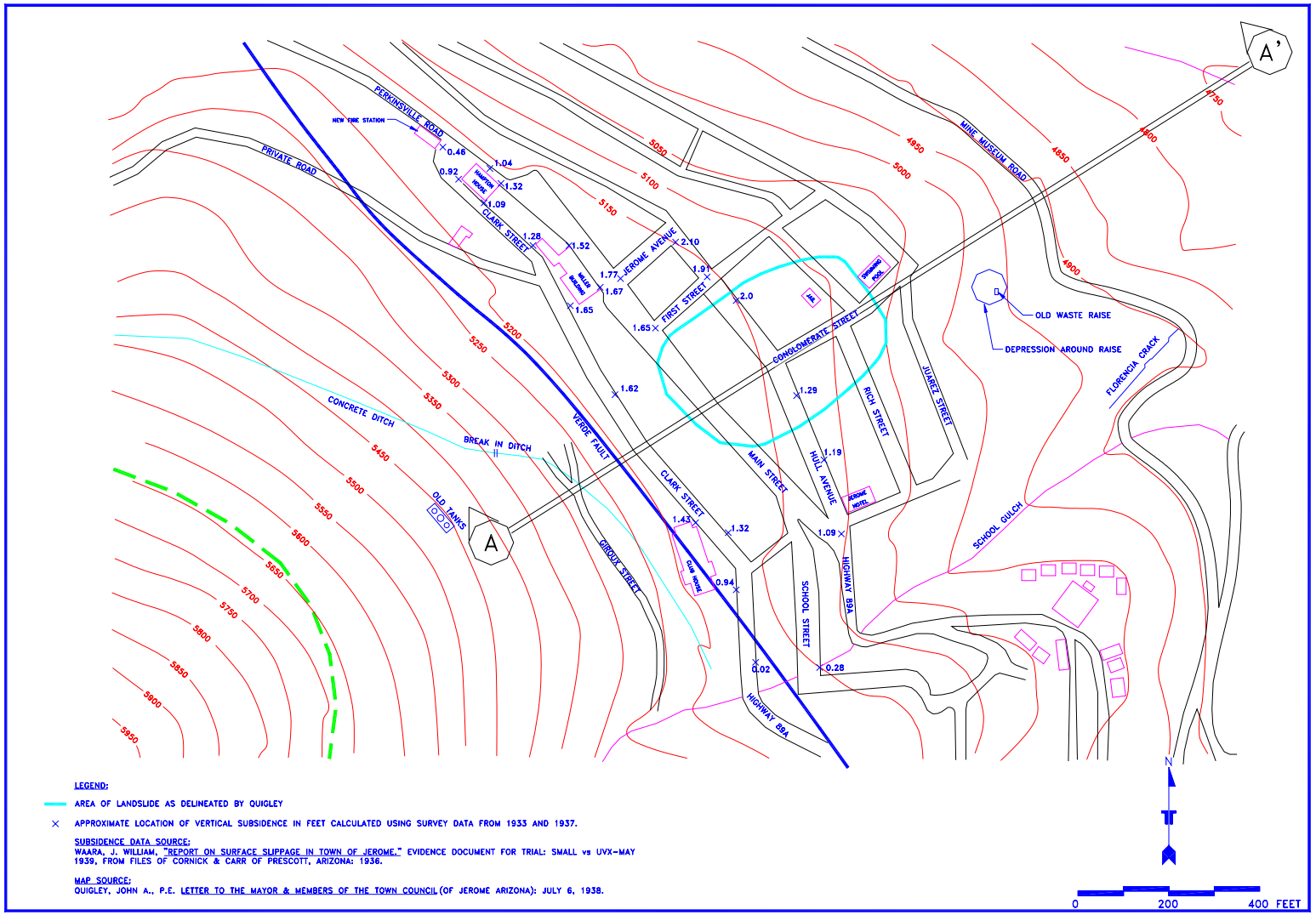
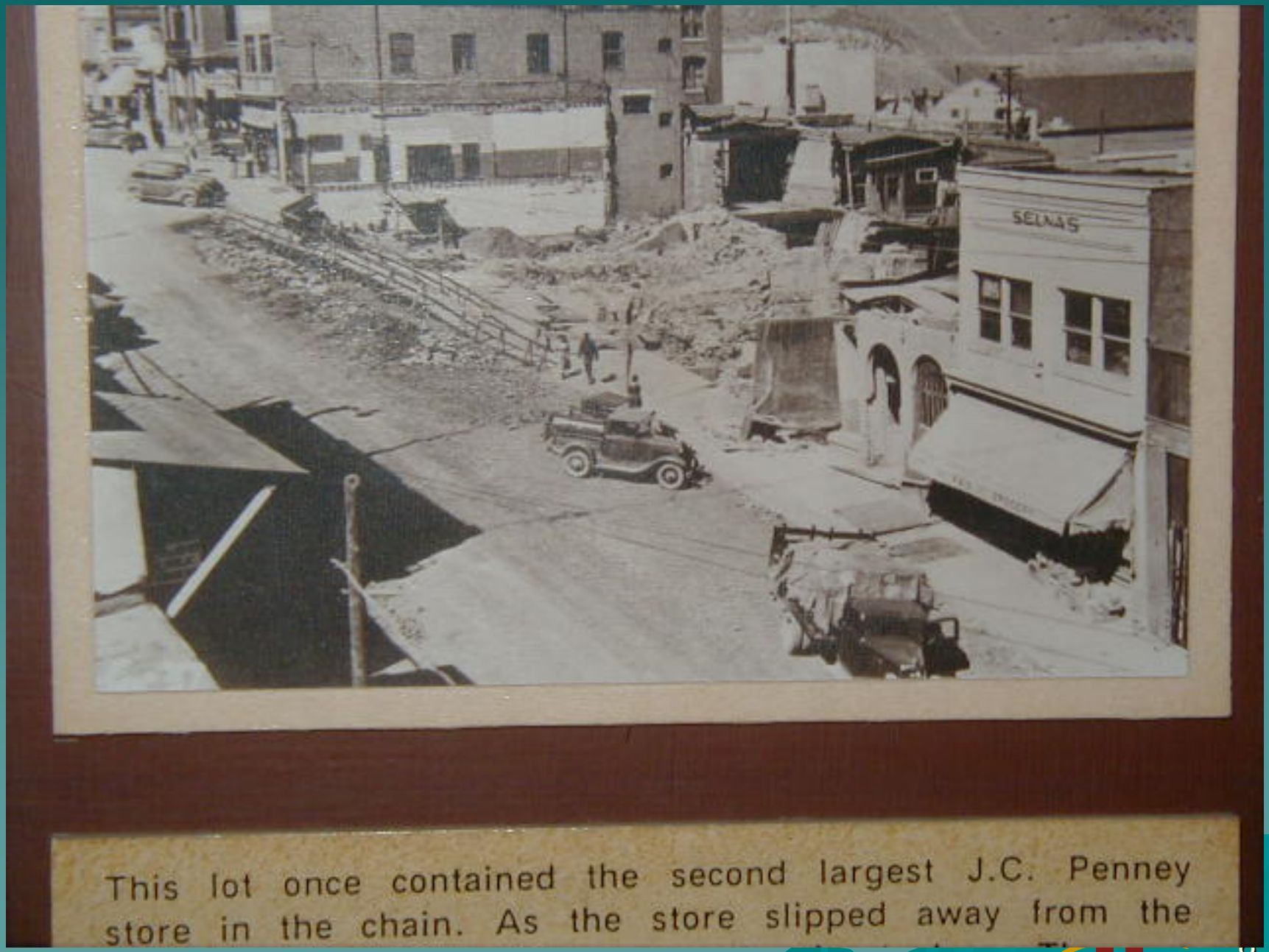


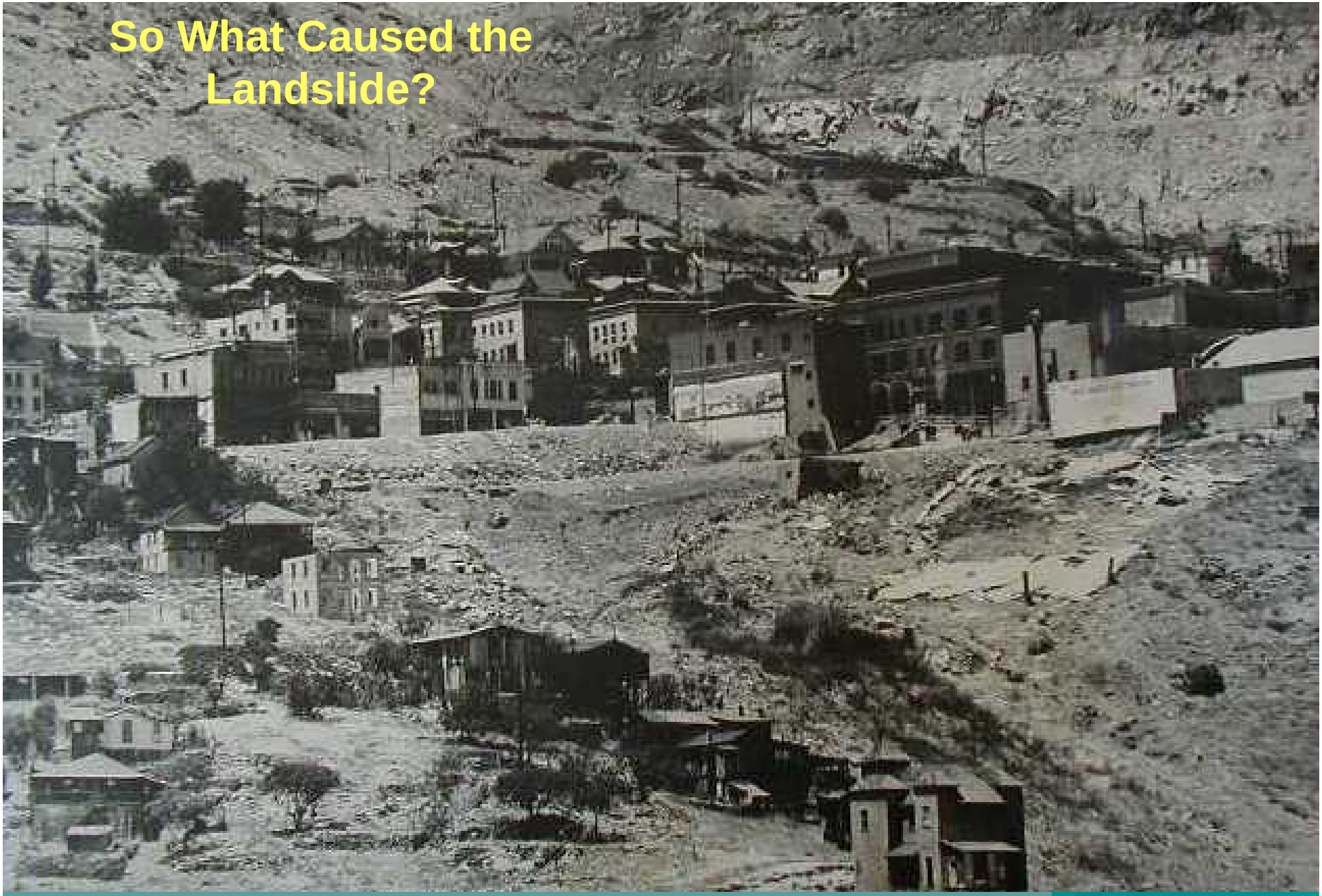
FIGURE 1: Site plan of Jerome in 1936 depicting the areal extent of the landslide.



This lot once contained the second largest J.C. Penney store in the chain. As the store slipped away from the

Proposed Site of Jerome Rest Area Structure

So What Caused the Landslide?



Potential Causes

- Low shear strength soils in the near surface;
- High groundwater conditions
  - caused by heavy rainfall events,
  - leaking water and fire pipelines,
  - surface water concentration near the head scarp, and
  - breaks in the concrete ditch on Cleopatra Hill immediately above the slide area.
- Assimilated seismic events
  - created by Coyote blasts at the United Verde Mine, and
  - mine blasts from the UVX Mine.
- A seismic event in 1931.

Potential Causes cont'd

- Movement along the Verde fault and a subsequent potential for change in the groundwater regime;
- Oversteepening of some slopes to construct buildings (such as on the fill sides of Main and Hull).
- Soil creep - the ground may have begun to creep in the mid 1920's and continued to creep until the remaining factors came together to cause significant mass movement and the landslide in 1936.

Historical Summaries

- The Town of Jerome
- United Verde Mine – 1888 to 1953
  - Coyote Hole Blasting
- United Verde Extension Mine – 1912 to 1935
- The Major Landslide in Jerome – 1924 to 1939
  - Landslide
  - Arbitration
  - Small verses UVX

SUBSURFACE CONDITIONS

- Geology
- Geomorphology
- Site and Regional Seismicity
- Soil and Bedrock Conditions
- Field Test Results
- Inclinometer Measurement Results
- Time Domain Reflectometry Results
- Laboratory Test Results
- Groundwater Conditions

Geology

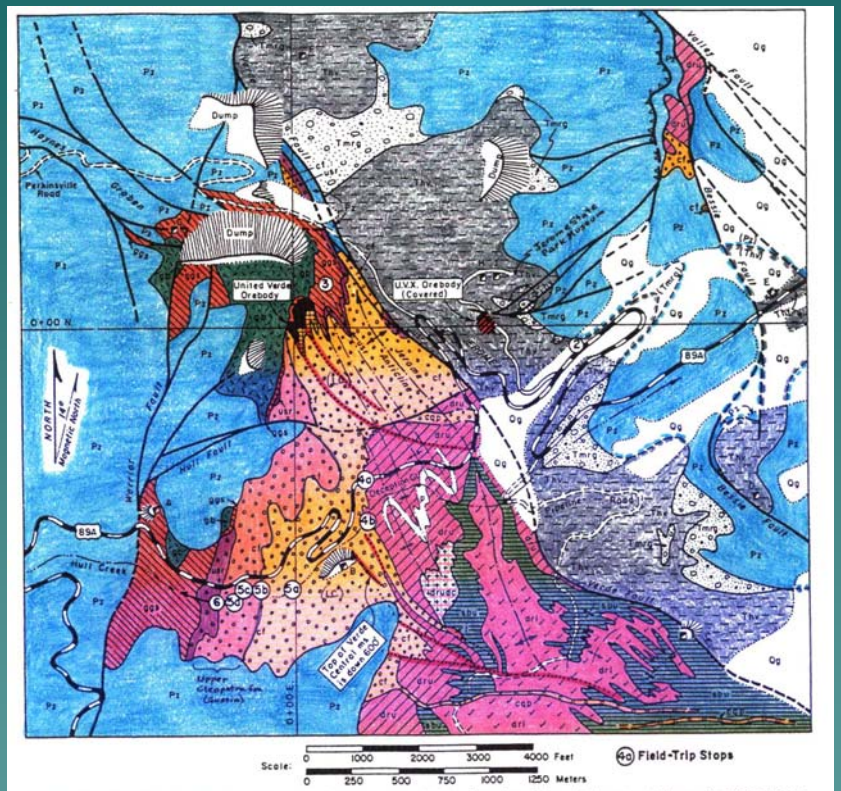


Figure 2. Simplified geologic map of the Jerome area, Verde district, Yavapai County, Arizona (modified from Lindberg, 1986a). Post-1971 detailed contact mapping modifies the interpretations and nomenclature of Anderson and Creasey (1958) and Anderson and Nash (1972). Current informal district usage is given below.

MAP SYMBOLS:

- Shafts: A=Jerome Grande, B=Verde Central, C=Verde Combination, D=Gadsden, E=Texas, F=A&A, G=Haynes, H=Edith & I=Audrey
- F_1 Folds (NNW) & F_2 "Cross Folds"
- Proterozoic Cauldron Faults
- Tertiary Faults; Laramide/Miocene

PHANEROZOIC ROCKS:

- Qg Quaternary Alluvium
- Thv Miocene Hickey Basalt
- Tmrg Pre-Miocene Conglomerates
- Pz Paleozoic Sediments; Undiff.

PROTEROZOIC ROCKS:

- gb Synvolcanic Intrusive Gabbro Sill
- ggs Grapevine Gulch Fm; Volcaniclastic Sediments, Tuffs
- usr Upper Succession Rhyolite/Dacite Domes & Breccias
- ms United Verde & U.V.X. (Concealed) Massive Sulfides
- bs Mg-Chlorite Alteration Zone ("Black Schist")
- cf Cleopatra Formation; Undiff. Rhyodacitic Extrusive
- cqp Cleopatra Quartz Porphyry Dikes
- ms Verde Central Massive Sulfide Horizon
- dru "Upper Deception Rhyolite" with Polygonal Flow (p)
- drudc Dacitic Dome within "Upper Deception Rhyolite"
- sbu "Upper Shea Basalt"; Includes Minor Rhyolitic Strata
- drl "Lower Deception Rhyolite" Flows & Breccias

Lindberg and Gustin 177

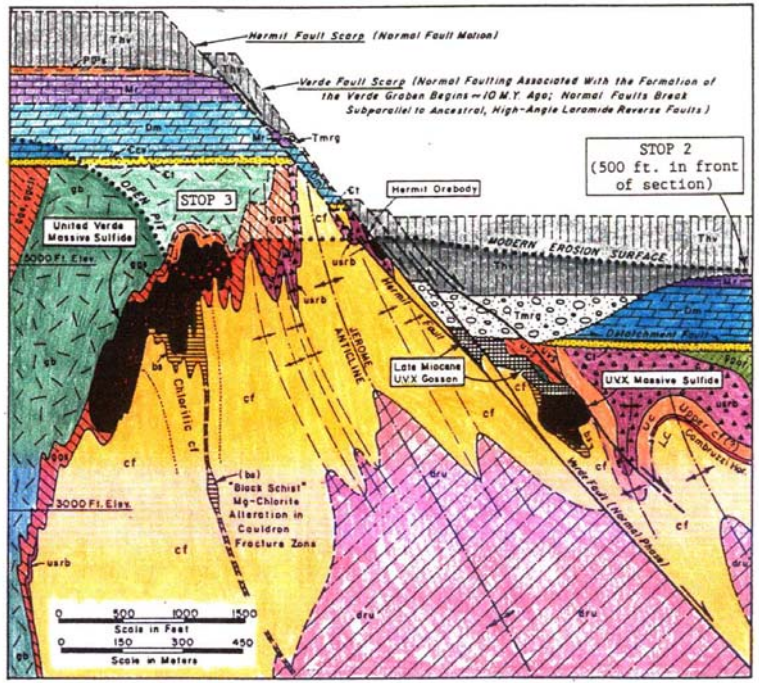
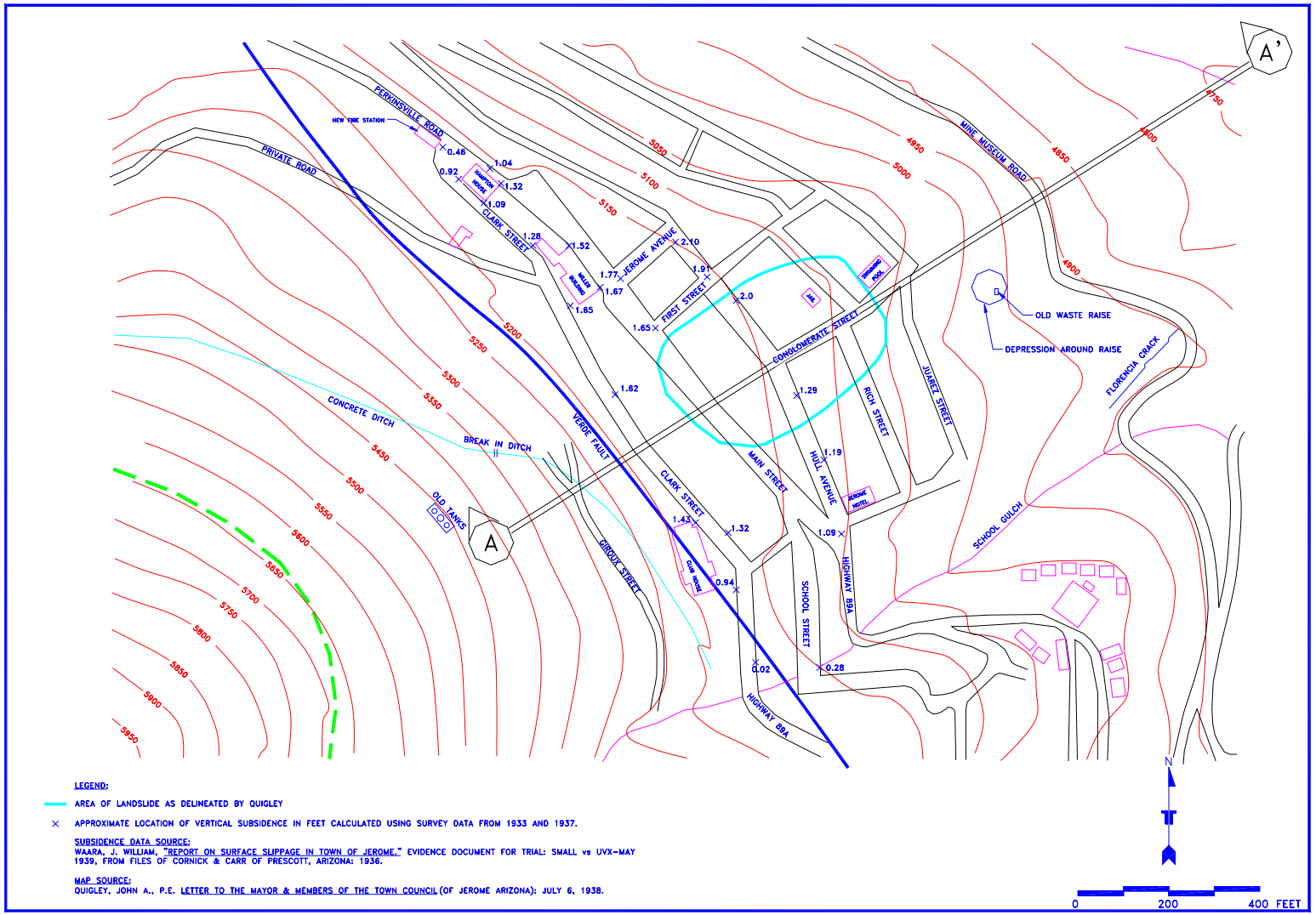


Figure 3. East-west cross section, looking north, through the Jerome anticlinorium. Geologic notations are given in Figure 2. The time is about 10 Ma when normal Verde graben faulting began. The United Verde and U.V.X. are separate orebodies which are now located on opposite limbs of the fold system.

View of Site and UV Mine



LEGEND:

AREA OF LANDSLIDE AS DELINEATED BY QUIGLEY

× APPROXIMATE LOCATION OF VERTICAL SUBSIDENCE IN FEET CALCULATED USING SURVEY DATA FROM 1933 AND 1937.

SUBSIDENCE DATA SOURCE:
WAARA, J. WILLIAM, "REPORT ON SURFACE SLIPPAGE IN TOWN OF JEROME." EVIDENCE DOCUMENT FOR TRIAL: SMALL vs UVX-MAY 1939, FROM FILES OF CORNICK & CARR OF PRESCOTT, ARIZONA: 1936.

MAP SOURCE:
QUIGLEY, JOHN A., P.E. LETTER TO THE MAYOR & MEMBERS OF THE TOWN COUNCIL (OF JEROME ARIZONA): JULY 6, 1938.

FIGURE 1: Site plan of Jerome in 1936 depicting the areal extent of the landslide.

Soil and Bedrock Conditions

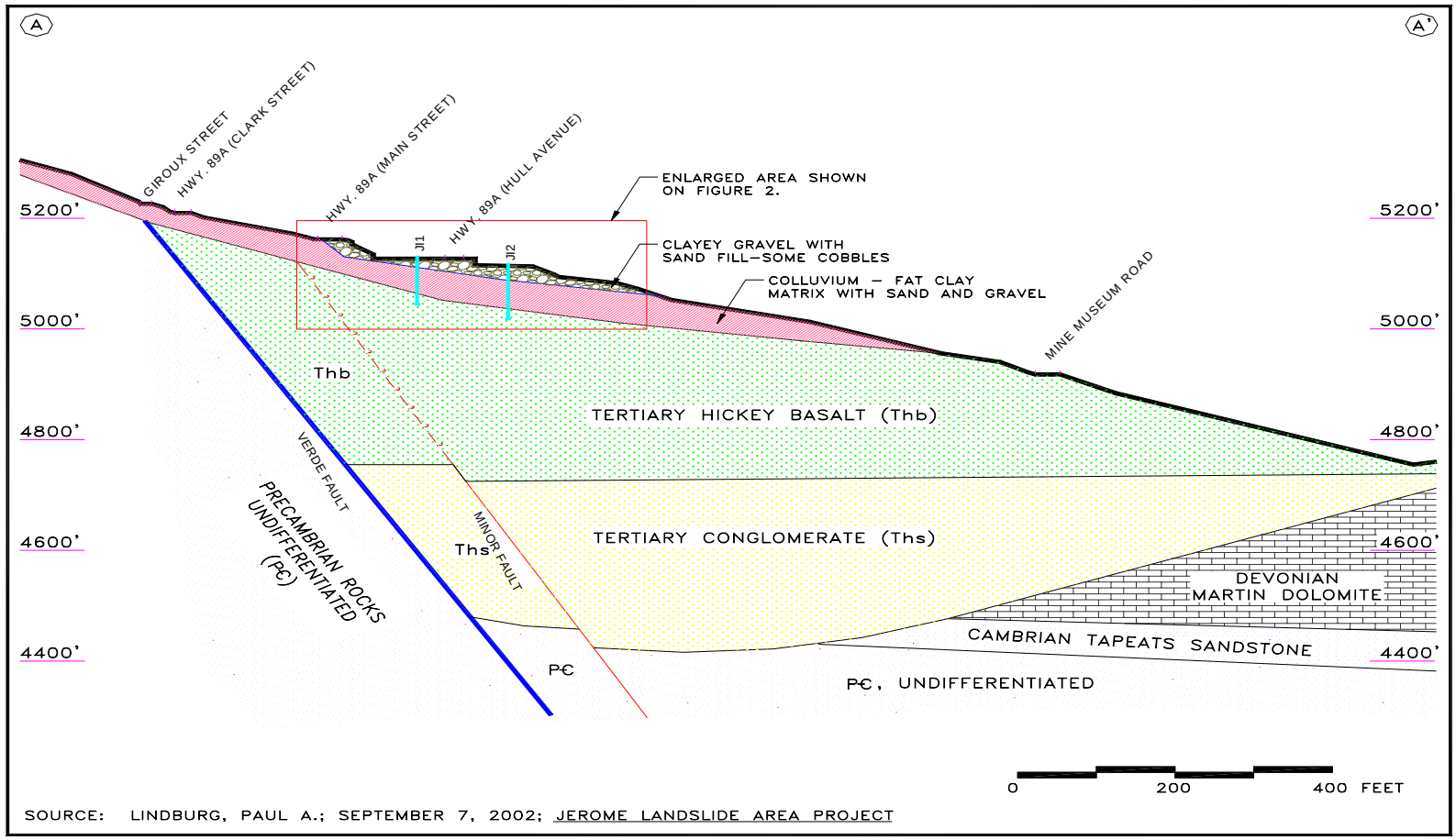


FIGURE 2: Cross section through landslide depicting geology and surface geometry.

Soil and Bedrock Conditions

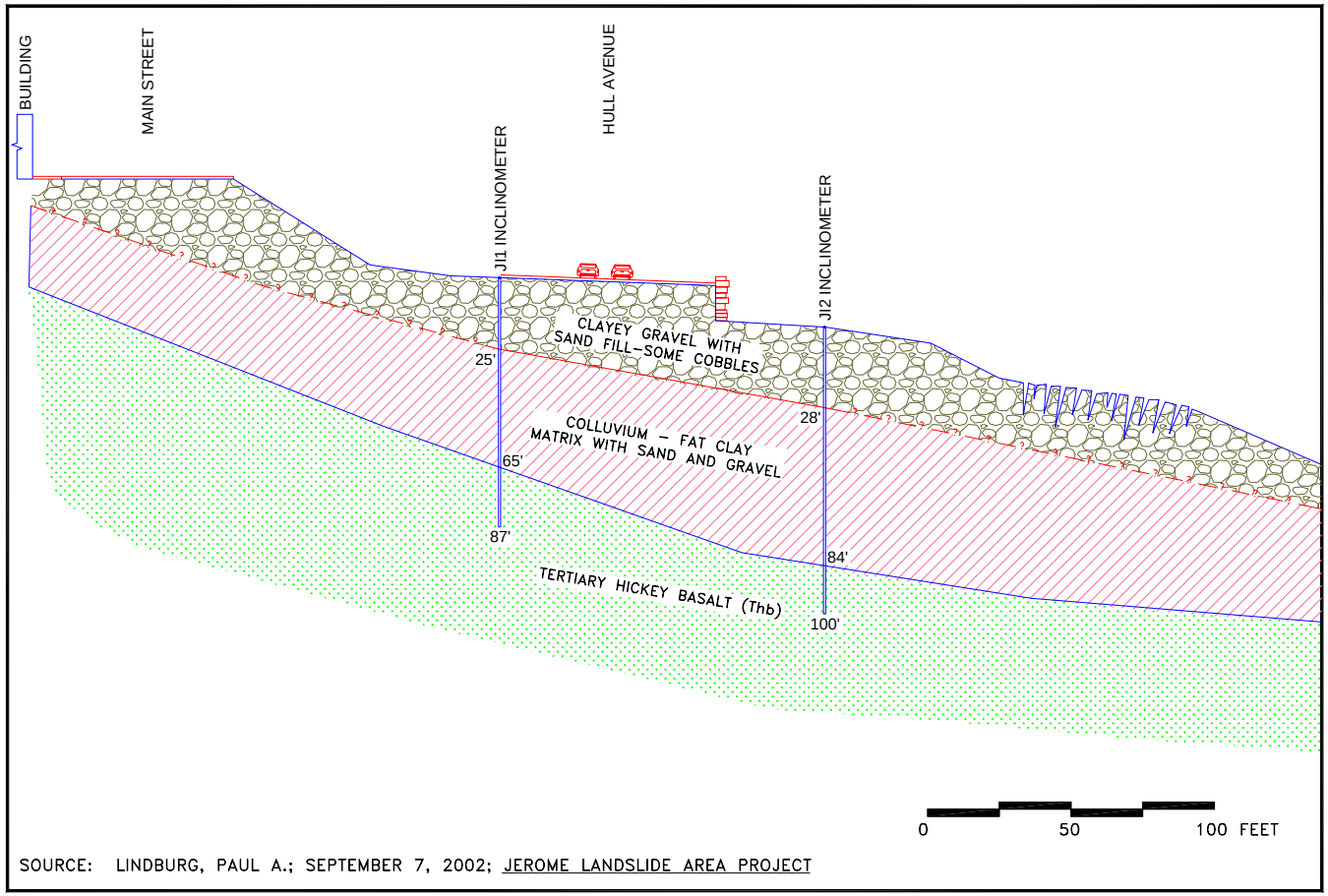
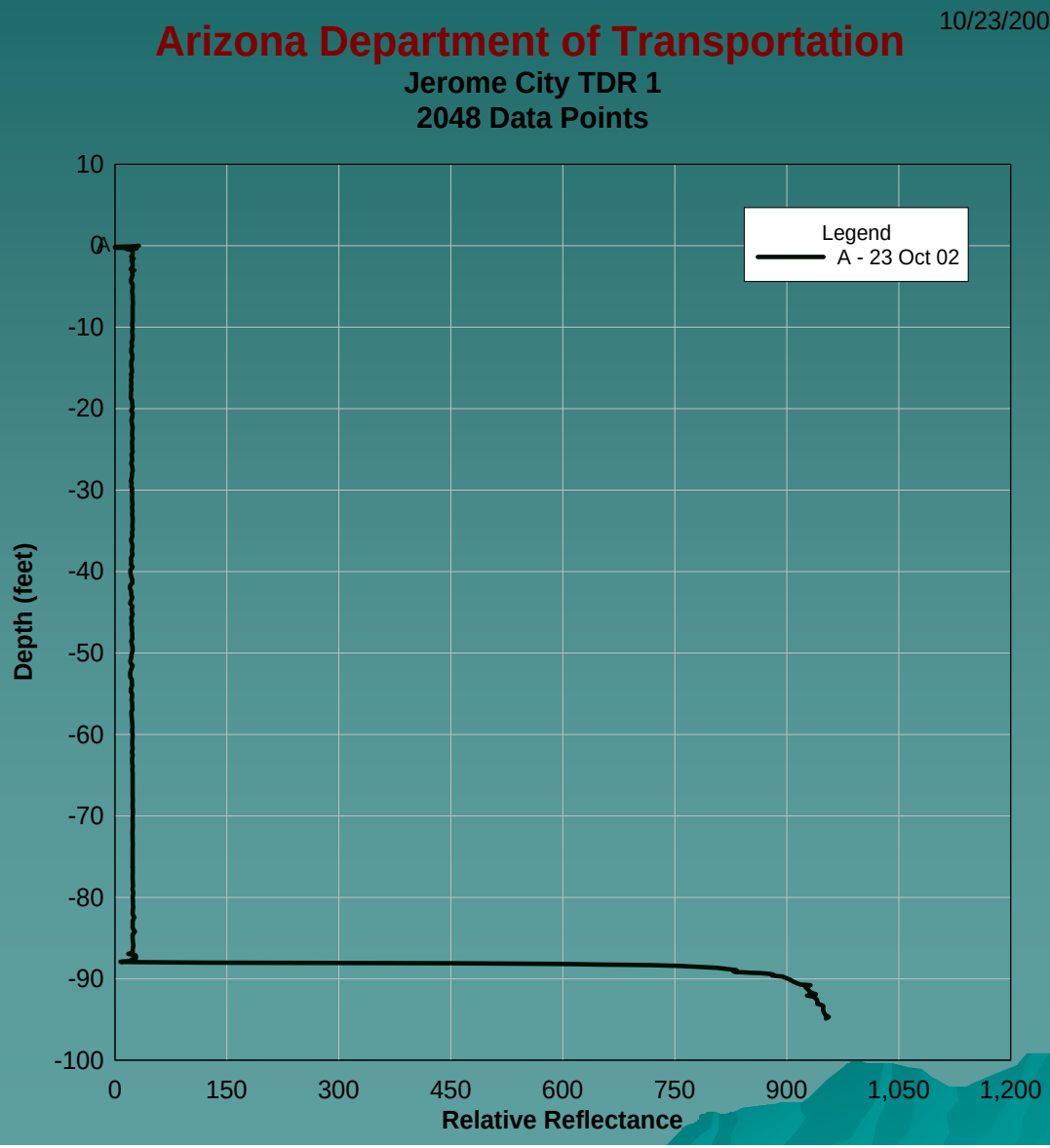
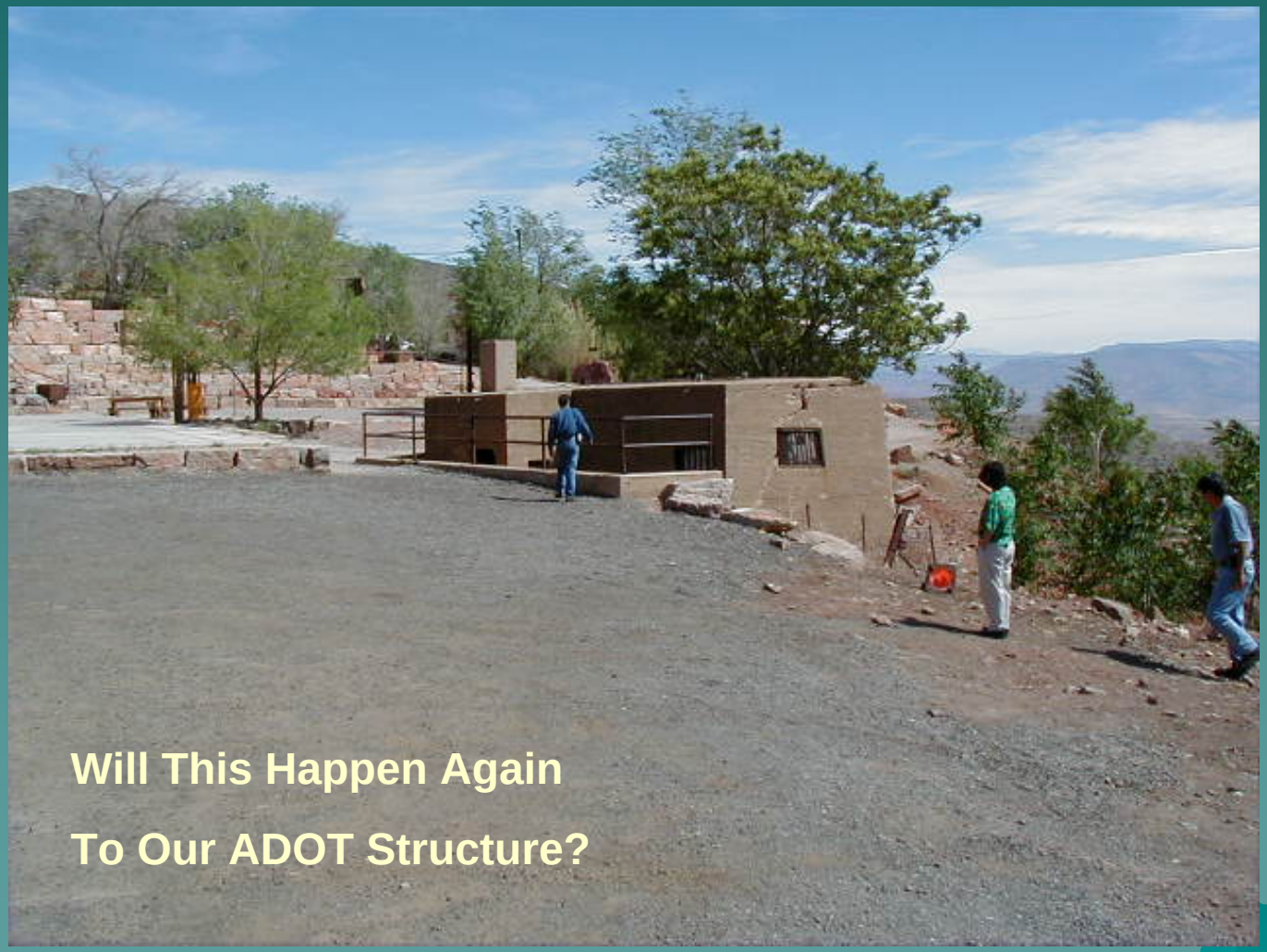


FIGURE 3: Close up of cross section shown in Figure 2.

Time Domain Reflectometry



Sliding Jail



Will This Happen Again

To Our ADOT Structure?

Sliding Jail

Cracked Building

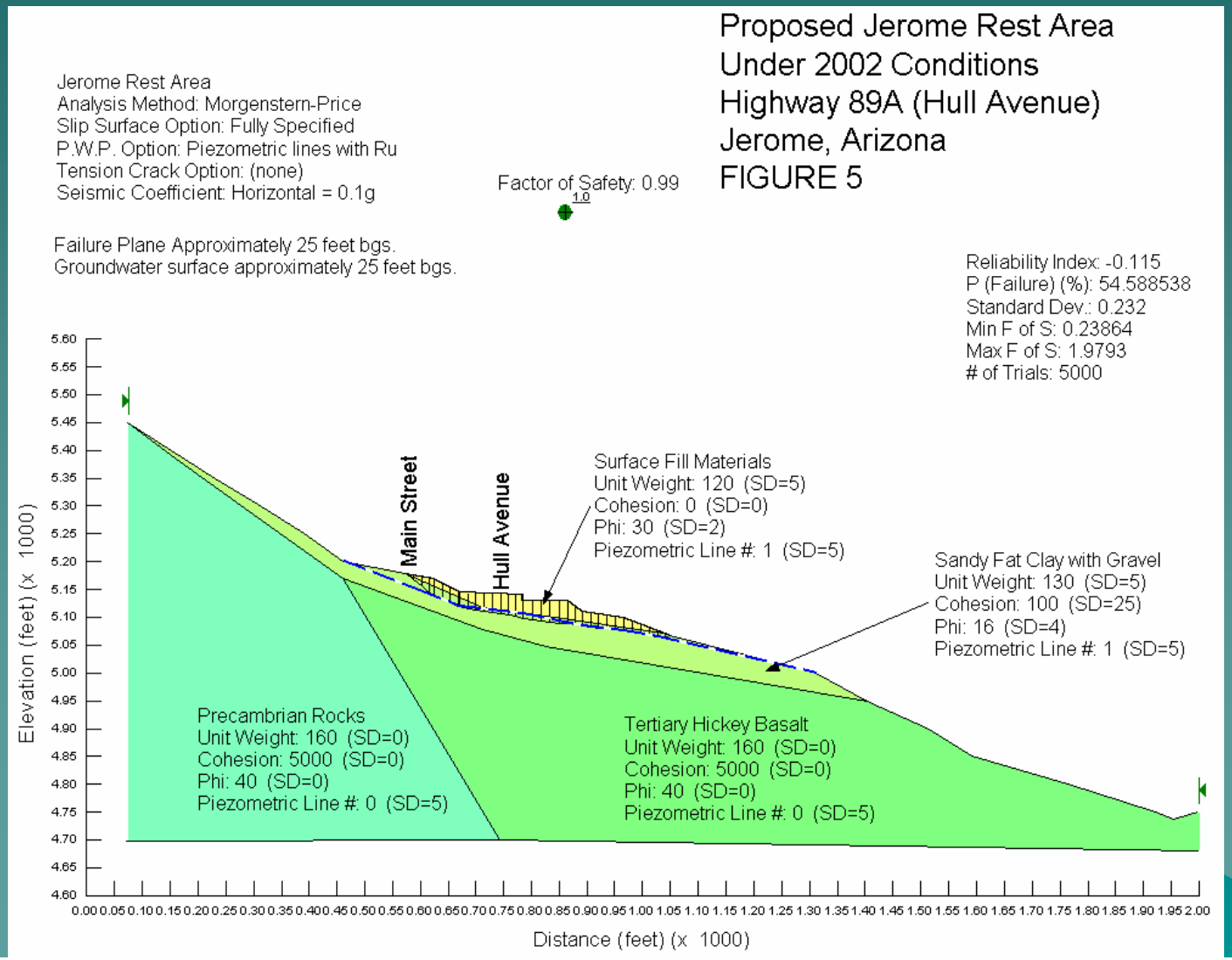
ENGINEERING ANALYSES

- **Landslide Characterization**
- **Mine Subsidence**
- **Causes of Landslide and Potential Causes for Recurrence**
  - Low shear strength soils in the near surface;
  - High groundwater conditions
    - caused by heavy rainfall events
    - leaking water and fire pipelines
    - surface water concentration near the head scarp
    - and breaks in the concrete ditch on Cleopatra Hill immediately above the slide area.
  - Seismic events and assimilated seismic events
  - Movement along the Verde fault from the Coyote blasts or the seismic event
  - Oversteepening of some slopes
  - Soil creep

ENGINEERING ANALYSES cont'd

- Strength Parameters
  - Residual Cohesion
  - Effective Residual Friction Angle
- Slope Stability Analyses

Slope Stability Analyses



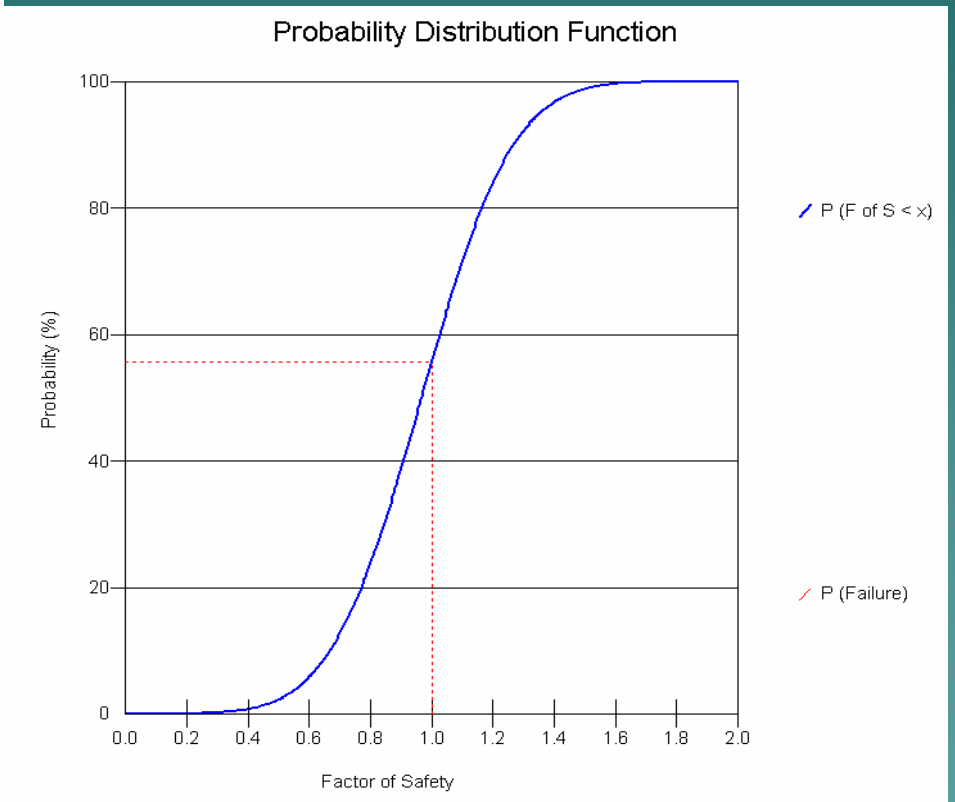
Summary of Stability Analyses

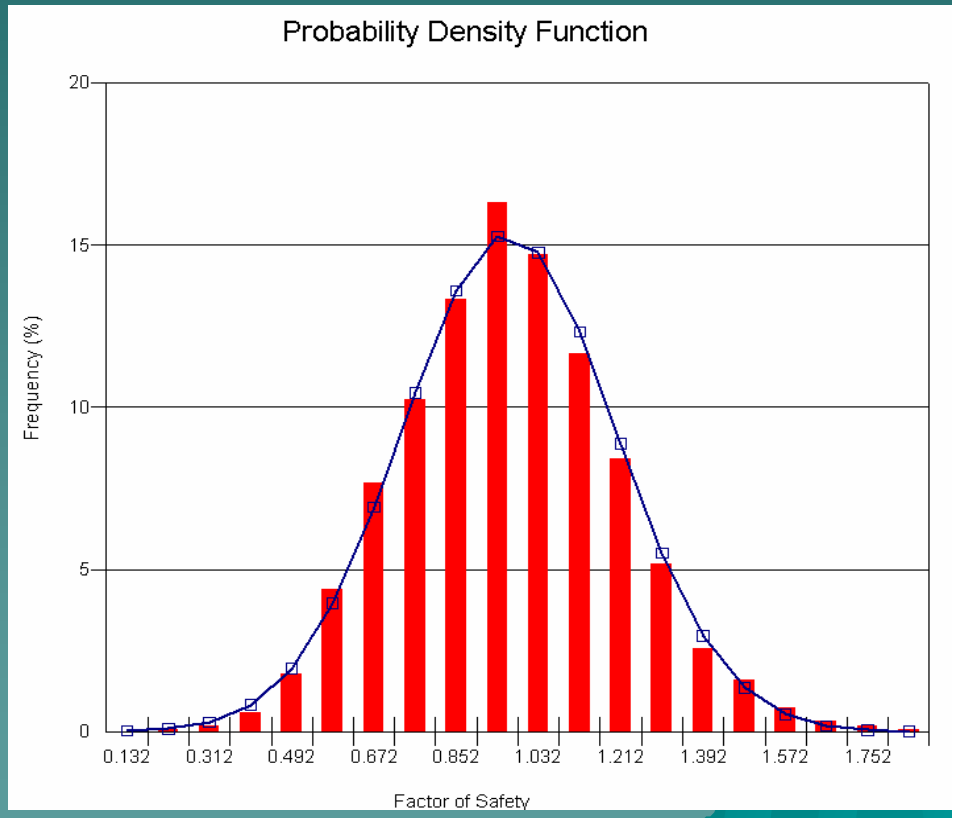
Condition Analyzed	Seismic Coefficient	Factor of Safety
1936	0.00g	1.0
2002	0.10g	1.0
	0.02g	1.3
	0.00g	1.5

Risk Analysis

- The accuracy with which the factor of safety for a given slope can be determined, is based on the following most significant factors:
  - Variability of surface conditions
  - Variability and type of subsurface conditions
  - Validity of the analytical method
  - Validity of simplifying assumptions
  - Intensity of study
  - Certainty of the design loading conditions occurring

Probability of Failure





Thank You for Your Attention!